GEOLOGY OF SOUTHERN SANPETE VALLEY

NORTH OF STERLING, UTAH

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ABSTRACT

The stratigraphic section in the report are begins with the Arapien shale, Upper Jurassic in age and thickness unknown. The Arapien has two members: the lower is the Twelvemile Canyon, shale, red, and salt-bearing; and the upper is the Twist Gulch, siltstone and shale. The next unit is the Morrison formation which is conglomerate, sandstone, sitlstone, and red measuring 1000 feet. Above the Morrison formation is the Indianola group which is divided into four formations of which three are found in the report area. At the bace of the group is the Sanpete formation whic is sandstone 1400 feet thick. Next is the Allen Valley shale, gray, 900 feet thick. Then is the Funk Valley formation whic is sandstone and shale 2440 feet thick. At the top of the group but not exposed in the report area is the Sixmile Canyon formation which is sandstone. The Indianola group is Cretaceous in age. The Indianola and older units are below an angular unconformity, the unit above is the North Horn formation which is below a second angular unconformity. The North Horn formation is sandstone, conglomerate, and shale 200 feet thick, and is Cretaceous and Tertiary in age. Above the upper angular unconformity is the Flagstaff limestone, white, massive, cherty, and 650 feet thick. Above the Flagstaff limestone is the Colton formation, sandstone, red and 30 feet thick. Next is the Green River formation which is white limestone, green siltstone and mudstone, and 201 feet thick. Above the Green River formation is the Crazy Hollow formation, sandstone, white, and 240 feet thick.

The structure in the area includes a large anticline of Indianola and older units which were eroded level. The anticline is overturned to the west and the axis trends north-south. A syncline is imposed 1000 yards to the east of the anticline axis and also trends the same way. The syncline is composed of Flagstaff and younger formations. Major faults occur in the west part of the area and are part of the Gunnison fault whic runs north from the area.

Geomorphology of the area includes a major debris flow which came from Forbush Cove in Funks Canyon Sec. 1, T. 19 S, R. 2 E, and dammed the San Pitch river forming a lake. Sediments were deposited and later the water cut a channel draining the lake. Another lake was formed which still exists, Palisade Lake.

Geologic history of the area is basically deposition of sediments in a near shore sea which was interrupted by fluvial deposits. These units were folded and the anticline was eroded forming an angular unconformity. Later fluvial deposits and lake deposits covered the area. Later faulting and folding formed the major faults and syncline.

INTRODUCTION AND REGIONAL SETTING

This is a report on field work done in Sanpete Valley, central Utah, north of the town of Sterling, Utah, covering sections 20, 21, 22, 27, 28, 29, 32, 33, and 34, Range 2 E, Township 18 S, Sterling quadrangle. The report covers stratigraphy, structural geology, geomorphology, and geologic history of the area. This report is a result of field work done in the summer of 1968 as part of Geology summer camp of The Ohio State University. The area was between the Gunnison Plateau to the west and the Wasatch Plateau to the east. It is one of the few areas in Sanpete Valley where bedrock is exposed giving some connection the two plateaus (Refer to figure I)

The Wasatch Plateau is the northernmost of the High Plateaus of Utah and is about 10,000 feet in elevation. The plateau is deeply cut by many canyons, one of which, Sixmile Canyon, is directly east of the report area. The Wasatch Plateau is part of the distinct geological province of the Colorado Basin to the east. The west face of the plateau is a great monocline named for the plateau. The Gunnison Plateau is about 9,000 feet in elevation and is part of the Graet Basin geologic province. Therefore, the Sanpete Valley and the report area takes on special interest in being on the boundary between the two geologic provinces. The rocks are divided into two large sections: a lower succession of sandstone ans shale, marine in origin, and an upper, fluvial sandstone and limestones. In the report area the two rock units are separated by an angular unconformity.

I would like to acknowledge the work of my two field workers, Dan Bush and Sheilla Cluggish. I would also like to thank the staff of the summer field camp especially Dr. Collison and Dr. Threet. I would like to thank Dr. White for helping me write the report.

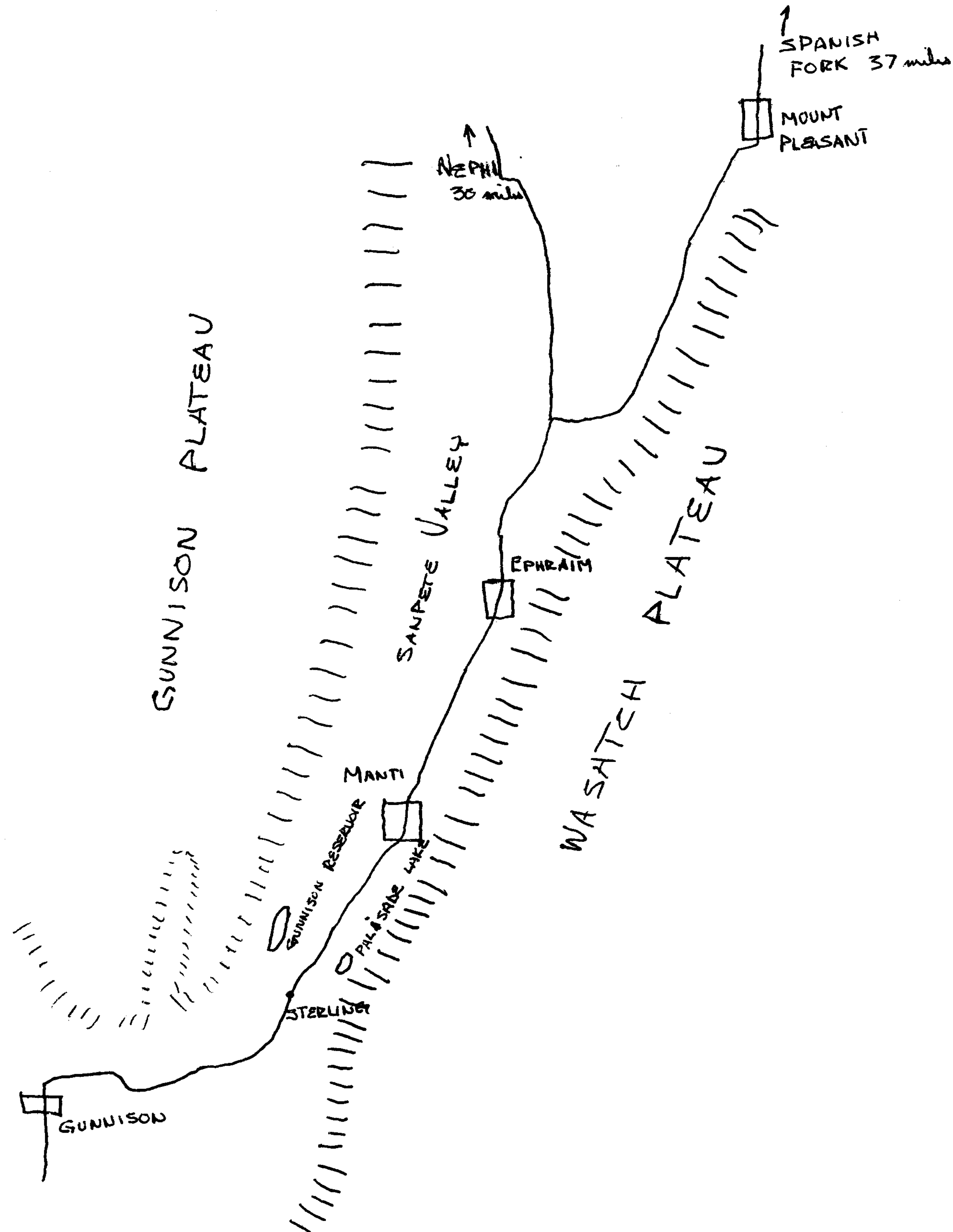

SPANISH FORK 37 miles
MOUNT PLEASANT
NEPHI
30 miles
GUNNISON PLATEAU
SANPETE VALLEY
EPHRAIM
WASATCH PLATEAU
MANTI
GUNNISON RESERVOIR
PALISADE LAKE
STERLING
GUNNISON

FIGURE # 1

STRATIGRAPHY

General nature of the Stratigraphic Sequence: The rocks present in the report area range in age from Upper Jurassic through Tertiary. The units recognized in the area are tabulated below.

System	Group	Formation	Character	Thickness
Tertiary		Crazy Hollow fm.	sandstone, white quartz, black chert	240
		Green River fm.	white limestone, green siltstone mudstone	201
		Colton fm.	sandstone, fine red subangular	30
		Flagstaff fm.	limestone, white massive, gray lithographic	0-650
		unconformity		
Cretaceous		North Horn fm.	conglomerate, sandstone, shale	0-200
		unconformity		
	Indianola	Funk Vally fm.	sandstone buff, gray shale unit middle	2440
	Indianola	Allen Valley fm.	shale gray, covered by alluvium	900
	Indianola	Sanpete fm.	sandstone, massive, crossbedded	1400
Jurassic		Morrison fm.	conglomerate, sandstone, siltstone, limestone	1000
	Arapien	Twist Gluch mbr.	siltstone, shale, red	?
	Arapien	Twelvemile C.	shale, red, salt-bearing	?

Arapien Shale: The Arapien shale refers to a body of red marine shale, fine grained sandstone found $\frac{1}{2}$ mile west of Sterling. It was named for Arapien Valley which is six miles southeast of the city of Gunnison. The thickness is unknown in the report area due to the poor exposures and because of the tight folding that has taken place. It has been estimated by Spieker (1946, p.125) to be 10,000 feet thick. The Arapien can be divided into two members; the upper Twist Gulch and the lower Twelvemile Canyon, both are present west of Sterling. The lower member is a red marine shale containing salt and gypsum.

No bedding was seen and no measurement of thickness was possible. The lower Twelvemile Canyon member was traced north through the report area east of Gunnison Reservoir upper member, the Twist Gulch member, was recognized only in the outcrop west of Sterling. Due to the poor exposure no measurment was possible and the contacts were covered. The upper member is gray, fine-grained sandstone. Both of the members were seen to the south, outside of the report area. No fossils were found, but fossils found by J. B. Reeside (Spieker, 1946 p.125) date the Arapien as Upper Jurassic.

Morrison Formation: The Morrison formation refers to a series of red conglomerate, shale, sandstone, and freshwater limestone beds found above the Arapien shale. In the report area the Morrison formation is found west of Gunnison Reservoir Dam and the exposed section was 1,000 feet in thickness. There they are exposed in near vertical, overturned beds forming steep cliff faces. The lower contact with the Arapien formation is covered by alluvium but is thought to be intertonguing (Spieker 1946, p.125). The lower beds are characterized by freshwater red limestone lens, shale beds, and conglomerate beds containing limestone, sandstone, and conglomerate cobbles. The upper beds exposed were lacking the freshwater limestone lens and the conglomerate cobbles are predominately quartzite. The upper contact is an angular unconformity of the Flagstaff formation over the Morrison formation. The Morrison formation is assigned to the Upper Jurassic on the basis of stratigraphic evidence and lithologic similarity to the type section. The Morrison formation represents a differential uplift and the resulting fluvial deposits. The change in the conglomerate cobbles is due to the exposure of older pre-Cambrian rocks in the source area.

Indianola Group: The Indianola group refers to a series of sandstone and shale units present along the base of the Wasatch Plateau. In the report area the group is well exposed due to the lack of the younger units that usually make the face of the plateau. The Indianola group includes the lower Sanpete formation, the Allen Valley shale, the Funk Valley formation, and the Sixmile Canyon formation just to the east of the report area. All of the formations are upper Cretaceous (Spieker 1945, p.126).

Sanpete Formation: The Sanpete formation refers to the lower unit of the Indianola group and consists of sandstone and minor amounts of conglomerate. The name of the formation is taken from its occurrence in the report area in Sanpete Valley. The lower contact with the Morrison formation is covered by the valley alluvium as is most of the lower beds. The uppermost beds are exposed as a hogback trending north northeast. The Sanpete formation is white, course to fine grained, calcareous sandstone. About half of the beds are cross bedded with minor amounts of conglomerate. The upper contact is covered by the alluvium of the Allen Valley formation. Total thickness is 1,400 feet. The Sanpete formation was formed in a marine near shore zone that received sediments from the west (Spieker, 1946, p.127).

Allen Valley Shale: The Allen Valley shale refers to the marine shale that lies between the lower Sanpete formation's sandstone and the Funk Valley formation's sandstone. The name for the formation is taken from the occurrence in the report area, Allen Valley. The entire unit is covered by alluvium and the contacts were not seen. The Allen Valley shale is evenly bedded, gray shale, marine in origin. The unit was measured 900 feet thick. The Allen Valley shale is thought to have been formed in either an embayment of the sea or a deeper water zone than the Sanpete zone. In either case calmer water allowed the deposition of shale.

Funk Valley Formation: The Funk Valley formation refers to a unit of sandstone with a middle shale member occurring in Funk Valley in the report area. The lower contact is covered by the alluvium in Allen Valley.

The Funk Valley formation consists of three units; a lower sandstone exposed in the hogback forming the east boundary of Allen Valley, a middle marine shale unit forming Funk Valley, and a upper sandstone forming the face of the plateau. Both of the sandstones are orange-brown when fresh, weathering to gray, medium grained, friable, crossbedded, and consists of 95% quartz. Total thickness is 2,440 feet. The upper contact is hidden below the Flagstaff limestone units lying unconformably over the Funk Valley formation. The environment of deposition is the same as during the time of the Sanpete formation and the Allen Valley formation.

North Horn Formation: The North Horn formation is exposed 0.6 of a mile north of Gunnison Reservoir Dam in the report area. The formation is named for the type locality North Horn Mountains on the east edge of the Wasatch Plateau. In the report area the North Horn formation refers to a series of red-brown sandstone, shale and conglomerates that varied in thickness from 0-200 feet. The lower contact is an angular unconformity over the Morrison formation. In other areas a lower unit of conglomerate is seen, the Price River formation. The North Horn conglomerate consists of gray quartzite pebbles in a calcareous sandy matrix. The sandstone is brown, fine-grained, rounded quartz with black chert, and is in a calcareous cement. The shale is gray, and forms slopes between the sandstone and conglomerate cliffs. The upper contact is an angular unconformity with the Flagstaff limestone. In other areas, however, the two units are conformable. The North Horm formation is a flood-plain deposit that derived its material locally from the Morrison formation sediments. The North Horn formation does not occur in the center of the Sanpete Valley. Much if not all of the unconformity with the Flagstaff limestone could be due to primary dip of deposition of the deposits. In areas without the local unconformity the North Horn contains near zero primary dip. No fossils were found in the report area but fossils identified by J. B. Reeside (Spieker, 1946, p.134) dates the North Horn as late Cretaceous and early Tertiary.

Flagstaff Limestone: The name Flagstaff limestone refers to lacustrine limestones present in the ridge 0.4 miles west of Gunnison Reservoir Dam in the report area. The formation is named for the type locality, Flagstaff Peak in the Wasatch Plateau. The Flagstaff limestone in the report area occurs in its typical form, white outcrops capping the top of the plateaus. The lower contact is an angular unconformity over either the North Horn formation or the Arapien formation. The thickness varies from 0-650 feet. The Flagstaff limestone is thickest to the west and thins to the east to where it is absent on the east side of the Sterling syncline. It is thought that during Flagstaff time a local high was present resulting in no deposition. The limestone is massive, white to gray, and contains some chert beds. There are some lithographic beds present. One sandstone unit occurs in the lower part of the unit. It is fine-grained, subangular, brown, and well cemented. The upper contact is thought to be gradational and possibly intertonguing but was not observed (Spieker 1946, p.136). The Flagstaff limestone is dated Tertiary in age and was deposited by a large lake that covered much of Utah (Spieker, 1946, p.136).

Colton Formation: The Colton formation is present only in the Sterling syncline 1.3 miles north of Sterling. The name of the formation is taken from the town near the type locality. The Colton formation consists of red-brown, fine-grained, subangular sandstone 95% quartz. The lower contact is gradational as is the upper contact. Both contacts may be intertonguing but no evidence was seen in the area. The Colton formation is dated Tertiary (Spieker, 1946, p.139) and resulted from well sorted fluvial deposits entering the lake. In other areas the Colton formation is absent and the Flagstaff limestone and the Green River formation are continuous (Spieker, 1946, p.136). The Colton formation represents a time when the lake receded. The Colton formation is 30 feet thick.

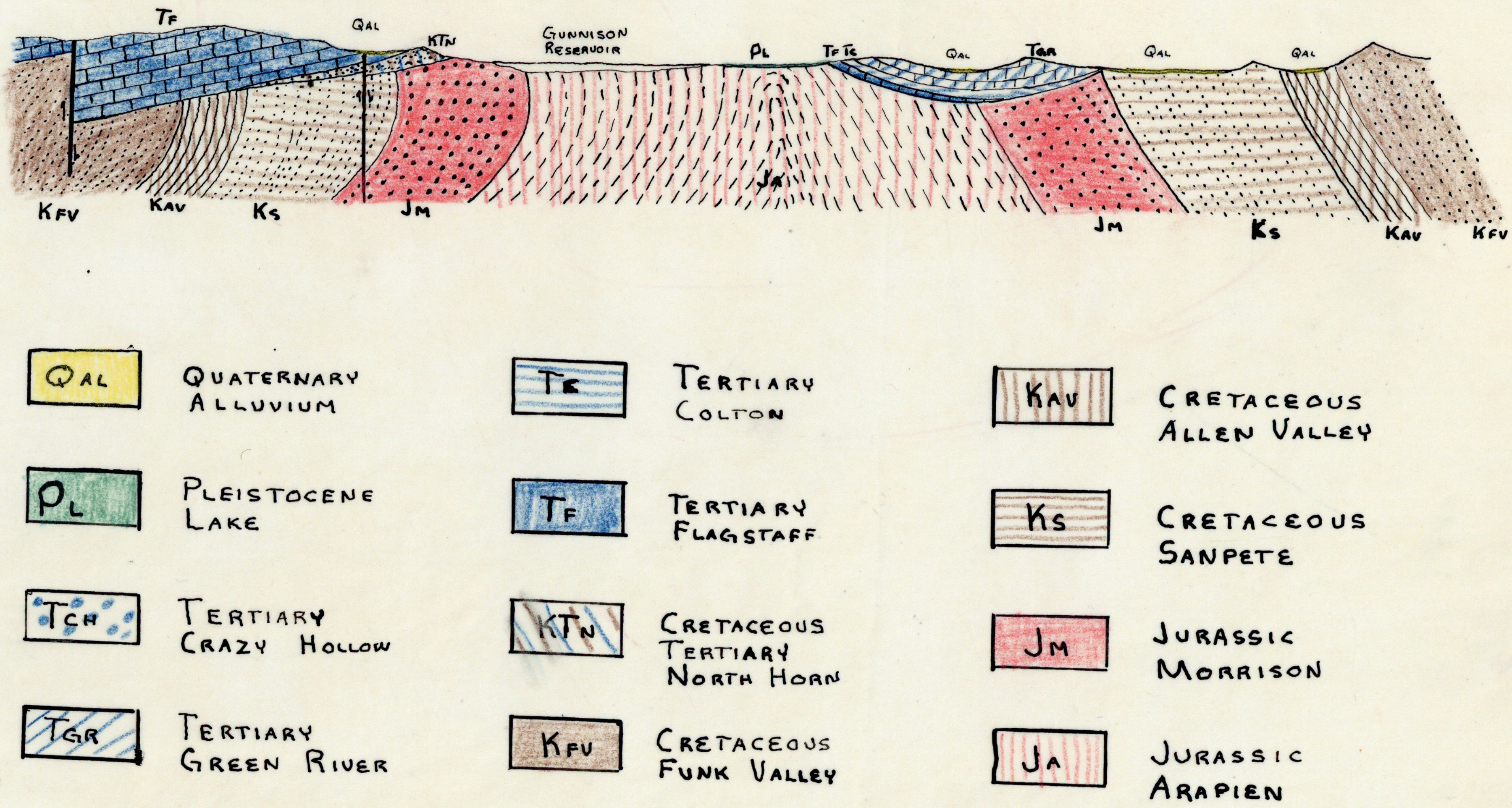
Green River Formation: The Green River formation is present 0.5 miles northeast and 1.1 miles north of Sterling in the Sterling syncline. The name is from the river exposing the type locality in eastern Utah. The Green River formation refers to the series of limestones, mudstone and siltstone found in the syncline. The lower contact is gradational with the Colton formation below. The limestone is similar to the Flagstaff limestone but the chert is a darker color, and some oolite is found. The mudstone is green, calcareous, fissil, and is a slope former. The siltstone is either green or red, limy, and a slope former. The thickness of the Green River formation is 201 feet. The upper contact is sharp. The Green River formation is Tertiary in age and was deposited by a lake that covered more area than did the Flagstaff lake (Spieker, 1946, p.140).

Crazy Hollow Formation: The Crazy Hollow formation refers to a unit of sandstone found in the Sterling syncline 1.4 miles north of Sterling. The lower contact with the Green River formation is sharp but is not seen well in the report area. The sandstone is of two types, both change laterally and occur throughout the unit. The first sandstone is red, calcareous, and fine grained 95% quartz and 5% black chert. The other sandstone has the appearance of "salt and pepper," is medium-grained, 90% quartz and 10% black chert, and friable. The second type is thought to be channel fills in the first type. The Crazy Hollow formation is Tertiary in age and originated as fluvial deposits covering the old lake beds.

STRUCTURAL GEOLOGY

In the area studied three important structures occur. The oldest is a major anticline made of the Cretaceous and older beds (not including the North Horn formation). The axis of the anticline trends N 30° W and runs in the middle of the Sanpete Valley. This anticline has been eroded and the younger rocks lie on an angular unconformity over the older. Over the crest of the anticline and trending in the same direction is a syncline named the Sterling syncline. To the north of the syncline the younger rocks have been thrust faulted to the west. Both the syncline and thrust faults are related in origin. The third structure is the existence of several large faults along the west side of the area. They are connected to the main fault that produced the Gunnison Plateau (students OSU field camp, 1968). (Refer to figure #2)

Cretaceous Anticline: The largest structure in the area is the major anticline that is formed in the Jurassic and Cretaceous rocks. This fold is classified as an overturned fold with the normal limb to the east and the overturned limb to the west. The normal limb generally has a strike N 25° E and a dip of 80° E. It is difficult to tell if the anticline is plunging or not due to the lack of exposures to the north. This fold is known to extend south through the Sevier Valley and north in the Sanpete Valley where it is seen at Wales Canyon. The start of the folding was after the Sixmile Canyon formation was deposited, but the time of the last movement is not as well defined. During the folding erosion was occuring. This leveled the anticline and when younger rocks were deposited over the anticline an angular unconformity was produced. During the time of the younger rock deposition the anticline was a site of a local high, as the younger units were deposited the high was covered forming onlap of the units. The Price River formation was not deposited in the



Cross Section
Lower Gunnison Area

Steve King

Figure #2

area at all. The Flagstaff limestone covered most of the area except the locality of the east limb of the Sterling syncline. The Colton formation is the first unit to completely cover the area.

Evidence exists, however, that during the time of deposition of the younger units the anticline was still being folded with at least the normal limb moving. This angular unconformity is different than the angular unconformity between the North Horn formation and the Flagstaff limestone west of the Gunnison Reservoir. The Sixmile Canyon unconformity has a greater difference between the attitude of the units, yet the strikes of the units are the same. West of Gunnison Reservoir the difference between dips of the units is only a 7° difference after correcting the Flagstaff to 0° dip and there is a 30° to 40° difference between the strikes. It may be more correct to say that the angular unconformity resulted from a difference in primary dip of deposition of the fluvial North Horn formation and the lacustrine Flagstaff limestone. Additional evidence supporting this theory is that the North Horn formation locally derived its material from the Morrison beds it rests upon. Primary dip is most common near the source of the beds deposited.

Sterling Syncline: The Sterling syncline named for the town of Sterling in the area rests on the eroded Cretaceous anticline. The syncline is symmetrical with both limbs having a dip of 20°. The axial trace curves through the area; north of Sterling it trends north but south of Sterling it trends N 20° E. The rock units in the syncline include all the units younger than the North Horn formation. Due to the fact that the syncline contains the younger units in the area the time of folding is not known exactly. It can be only said that folding occurred after Crazy Hollow time and before deposition of the valley gravel.

To the north of the syncline 2.2 miles north of Sterling the folding changes into thrust faults. The thrust is clearly a continuation of the fold; this is seen in the western thrust which has only a displacement of a few feet at the southern end but to the north the displacement becomes greater. The evidence for the existence of the west thrust is the drag folds exposed in the western railroad cut. In the drag fold zone in the Arapien formation below the Crazy Hollow formation there has been recrystallization of gypsum into shear cavities in the Arapien formation. By following this gypsum zone the thrust may be traced into the rock units of the syncline to the south. There are two local faults in the first thrust plate. The west fault is a low angle, rotational, normal fault. The eastern fault of the two is a high angle reverse fault. Both are thought to have occurred during settling of the thrust plate. The east thrust existence is uncertain because it is not exposed well at any place. The evidence for the existence of the thrust is the uniform difference of strike between the two thrust plates and the geomorphological expression of the surface. Between the two plates there is a small valley indicating a weakness in the rocks where the thrust contact would be.

The Sterling syncline and the thrust to the north are connected in origin. Two theories have been advanced to explain the source of the folding-thrusting pressure. The pressure could have resulted from regional pressure that would have effected both the Cretaceous anticline and the Sterling syncline. Such a pressure could have folded the anticline more tightly while at the same time slipping between the older and younger beds. However, it is hard to see why the pressure did not fold the anticline more and the younger units above into an anticline instead of a syncline. The second theory is that the movement of the Wasatch monocline provided sufficient force to form the syncline. North along the Wasatch front are many examples of block glide at the foot of the monocline. They either moved over the Flagstaff limestone after the monocline slope was formed or as the slope was being made. In either case if the Flagstaff limestone was replaced over Funk Valley where it has been eroded, the east limb of the syncline would lie at the foot of the monocline. The weight of the units on the slope would have provided sufficient force to form the syncline and thrust. Later the monocline slope was eroded away. The fact that the Flagstaff limestone is the unit being moved over in the monocline but is in the units that were folded is explained by the non-depositional area of the Flagstaff limestone in the east limb of the syncline. This allowed the western unit of the Flagstaff limestone to be folded.

Gunnison Fault: The faults occurring west of the Gunnison Reservoir are: the major fault which begins at the southern head of the valley west of Gunnison Reservoir and tends north in front of the Gunnison Plateau; a small fault, existence uncertain, starting west of the end of the Gunnison fault and trending sourh; and a major fault near the west edge of the area, existence of this fault is also uncertain. The Gunnison fault begins at the head of the valley and runs north along the Gunnison Plateau face. Near the northern part of the area the displacement is 300 feet. This was measured by a sandstone bed in the Flagstaff formation that was found on both sides of the fault. The downthrown side is to the east. The minor fault to the west and trending south of the Gunnison fault is uncertain in existence. Evidence for the fault is the difference in dips on either side of the fault, and the straight and narrow drainage along there. This could be a chevron fold instead of a fault. The major fault along the west side of the area is also uncertain in existence. The evidence for this fault is based upon cross sectional studies which show that if the Flagstaff limestone continued at the 10° to 13° dip the thickness would be far in excess of the measured thickness. No fault may exist, however, if the beds become level below the surface. A sandstone bed similar to the one found by the Gunnison Fault occures near the shed 2.3 miles northwest of Gunnison Reservoir Dam. If this is the same bed, the displacement of the west fault would be the thickness of the Flagstaff limestone. The age of the fault is not known with any certainity other than being younger than Flagstaff limestone, and probably younger than Crazy Hollow formation.

Other Faults: There are several other small faults in the Sterling syncline and the Cretaceous rocks. These are of small displacement and trend east-west. The evidence for the faults is observed displacement of the beds by the faults. The age of these faults are younger than the Crazy Hollow formation.

GEOMORPHOLOGY

The Quarterernary, pre-lake Sterling, pediment gravel, which occured before the debris flow, overlies some of the low Arapien formation and Crazy Hollow formation hills. The gravel deposits are composed mostly of limestone and chert, and the pebbles are generally angular in appearance. These gravel deposits are remmants of widespread pediments which once filled the valley, but have been eroded away. Southward flowing streams eroded the pediments leaving only these few remnants which were protected partially by the more resistant line of Green River formation hills.

In Pleistocene time a major debris flow came out of Forbush Cove in Funks Canyon in Sec. I T19S R2E, 2.0 miles east of Sterling. It flowed across the Sanpete Valley damming the southward flowing river and forming Lake Sterling (Threet, personal communication, 1968). Much of the material of the debris flow consists of stream rounded boulders that were picked up by the flow. Outwash from the flow material was deposited on either side of the body of the flow by fluvial action. This outwast is of the same material as the flow but has been stream worked. As the level of Lake Sterling rose it began to cut a channel in the dam and the lake was eventually drained. The lake deposits found in the area are clays, silt and sand, but no fossils were found in our area.

An example of double stream piracy occurs at the head of the valley 0.4 miles west of Gunnison Reservoir Dam. The original drainage imposed on the eneschelon faults of the area was changed when an advancing tributary of the main drainage, beheaded the drainage in the western fault. This drainage was in turn beheaded by an advancing tributary of the San Pitch River. This resulted in three 90° bends in the drainage pattern(Refer to figure #3).

FIGURE 3a

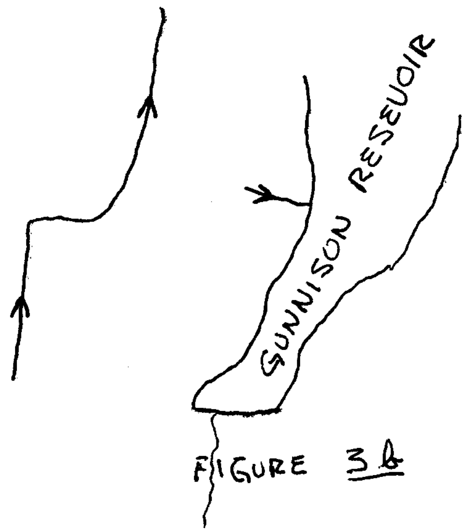


FIGURE 3b

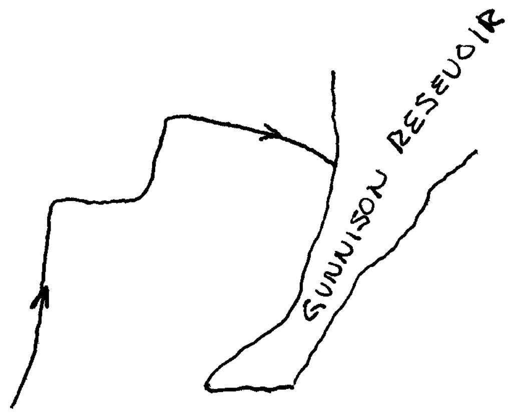


FIGURE 3c

Geologic History

During Jurassic time, the oldest time of which there is a geologic history present in the area, the area was covered by a highly saline sea. The high saline character of the sea was due to the sea being restricted in its outlet and due to a high evaporation enviroment. The result was evaporated deposits of gypsum and halite as well as the clay sized particals that made the marine shale. During later Jurassic times the sea retreated to the east. This was due to a differential uplift of the land to the west, deposition of cobbles and smaller fulvial particles. At first the source was paleocene rocks, limestones, sandstones, and conglomerates, later the source area was eroded to older rocks and quartzites.

During Cretaceous time the area was again covered by the sea. During this time the area received alternating sand and shale deposits. The shales represent a lack of larger sediments entering the area, a change in the distance to the shore line, and/or a estuary topography that would trap the sediments. The sandstones represent the opposite of these conditions. During later Cretaceous time the land wasn't receiving any sediments. A symmetrical anticline fold was produced either by east west compression, or by tension northwest - southeast or northeast - southwest. At the time of folding erosion was taking place and the sediments were being deposited somewhere else.

Near the end of the erosion and near the end of Cretaceous time and continuing into Tertiary time the area was covered by fluvial sands and gravel. The area at the axis of the fold wasn't covered by the sediments since this was still a high area. The primary dip of these sediments was about 10° north in the area west of the anticline and 10° east in the area east of, the anticline. Farther from the anticline the primary dips were near 0°. Following the fluvial deposits the area was covered by a large lake that deposited freshwater limestones in all the area except the high that still remained from before; however, this area is smaller than before and the limestone beds onlap over the beds below. The limestones have a primary dip of 0° form an angular unconformity with the fluvial deposits in the report area but in some other areas the beds are conformable. During later Tertiary times the lake was invaded by fulvial sediments mostly sandstone in this area. This is due to either a lowering of the lake level or to increased erosion due to a climate change. Following the clastics the lake conditions returned to deposit more limestone as well as shale and siltstone. Both of the limestones contain a great deal of chert. The chert was formed from silicic colloid that came from the solution of the volcanic products of other areas near the report area. Still during Tertiary time the lake was filled with chert and quartz particles.

During the late Tertiary or later time region pressures effected the area. Tension in a east west direction resulted in a regional dip of 10° to 15° west. This changed the symmetrical anticline into a overturned anticline. The same tension faulted the rocks in the area west of Gunnison Reservoir in an echelon pattern up on the west and down on the east. In the east part of the area the tension faulted the rocks below the surface but the fault didn't reach the surface. Instead the Tertiary rocks flexed over the movement of the fault down on the west and up on the east. It is possible that the sliding of the upper Tertiary beds on the early Tertiary beds resulted in the syncline and thrust structure in the center of the valley. The monocline could have been formed by a different pressure, compressional from the east and west. If this is true the syncline and thrust resulted from the compressional force. Later minor faults occurred cutting all older beds and structures. These faults may have resulted from continued movement of the monocline force in other areas. Later erosion removed the monocline beds and any beds that may have slid down the monocline face.

APPENDIX

MEASURED SECTIONS

Unit	Bed	Description	Thickness (feet)
Crazy Hollow formation		NE¼ SW¼ Sec. 27 T18S R2E 2.3 miles north of Sterling	
3	Sandstone	red, fine-grained, subangular to subrounded, 95% quartz, 5% chert, well sorted, regular bedding well cemented, ledge former, lower contact sharp	190
2	Sandstone	"salt and pepper", white when fresh, weathers yellow, medium-grained, subangular, 85% quartz 15% chert, well sorted, poorly cemented, ledge former, lower contact sharp	23
1	Sandstone	red, fine-grained, subangular to subrounded, 95% quartz, 5% chert, well sorted, regular bedding well cemented, ledge former,lower contact sharp	27
			240

Unit	Bed	Description	Thickness (feet)
Green River formation		SE¼ SW¼ Sec. 27 T18S R2E 1.1 miles NE of Sterling	
7	Limestone	gray-brown when fresh, weathers tan, cherty, oolitic in places, ledge former, lower contact sharp	23
6	Limestone	like unit #2	26
5	Mudstone	like unit #3	45
4	Siltstone	dark green, gray green when weathered, well consolidated, ledge former, lower contact gradational	11
3	Mudstone	green, calcareous, fissle, slope former, lower contact sharp	34
2	Limestone	white when frest, weathers yellow brown, massive, blocky, ledge former, lower contact sharp	38
1	Siltstone	green, weathers gray, calcareous, poorly consolidated, slope former	24
			201

Unit	Bed	Description	Thickness (feet)
Colton formation		NE$\frac{1}{4}$ SE$\frac{1}{4}$ Sec. 28 T18S R2E 1.4 miles north of Sterling	
1	Sandstone	red, fine-grained, subangular, 95% quartz, well sorted, well cemented, lower contact covered	30
			30
Flagstaff formation		NE$\frac{1}{4}$ SW$\frac{1}{4}$ Sec. 20 T18S R2E 1.9 miles north Gunnison Reservoir Dam	
18	Limestone	like unit #3	13
17	Chert	like unit #10	5
16	Covered Slope		52
15	Chert	like unit #10	3
14	Limestone	like unit #2	100
13	Limestone	like unit #3	97
12	Chert	like unit #10	23
11	Limestone	like unit #9	15
10	Chert	gray, weathers orange and gray, minor amounts $CaCO_3$, ledge former, lower contact sharp	14
9	Limestone	white, weathers gray, no chert, lithographic, regular bedding, basal contact sharp	44
8	Limestone	like unit #2	91
7	Sandstone	brown, fine-grained, subangular, quartz, well sorted, well bedded, well cemented, basal contact sharp	5
6	Limestone	like unit #2	42
5	Limestone	like unit #3	25
4	Limestone	like unit #2	9
3	Limestone	white, weathers light gray, fine-grained, massive, dence, slope and ledge former, basal contact sharp	35
2	Limestone	white to gray, weathers gray, massive, cherty, dence, ledge former, basal contact sharp	44
1	Covered slope		37
			650

Unit	Bed	Description	Thickness (feet)
North Horn formation		$SE\frac{1}{4}$ $SE\frac{1}{4}$ Sec. 29 T18S R2E 0.5 miles north of Gunnison Reservoir Dam	
5	Sandstone	brown, medium-grained, rounded to subrounded, quartz, well sorted, well bedded, well cemented, ledge former, bacal contact gradational	30
4	Conglomerate and Sandstone	conglomerate has fewer Morrison fm. derived pebbles, sandstone pebbles, matrix sandy red-brown, course to medium-grained, subangular, crossbedded, basal contact sharp	36
3	Shale	like unit #1, basal contact gradational	36
2	Conglomerate and Sandstone	red-brown, conglomerate is quartzite pebbles, sandstone matrix, sandstone is fine to course-grained, subrounded,crossbedded (top up) basal contact sharp	26
1	Shale	red, contains quartzite pebbles, bedding poor, slope former, basal contact angular unconformity	72
			200
Funk Valley formation		$NE\frac{1}{4}$ $NE\frac{1}{4}$ Sec. 34 T18S R2E 1.2 miles northeast of Sterling	
3	Sandstone	like unit #1	305
2	Shale(?)	covered by valley alluvium, thickness from map (Spieker, 1946, p. 127)	1550
1	Sandstone	orange-brown, weathers gray, medium-grained,subangular 95% quartz, well sorted, well bedded, some cross-bedding (top to east), ledge former, basal contact covered	585
			2440
Allen Valley formation		$NW\frac{1}{4}$ $NE\frac{1}{4}$ Sec. 34 T18S R2E 1.1 miles northeast of Sterling	
1	Shale(?)	covered by alluvium, thickness from map (Spieker, 1946, p. 127)	900
			900

Unit	Bed	Description	Thickness (feet)
Sanpete formation		$SE\frac{1}{4}$ $SE\frac{1}{4}$ Sec. 27 T18S R2E 1.6 miles northeast of Sterling	
5	Sandstone	like unit #3	49
4	Sandstone	like unit #2, no conglomerate	56
3	Sandstone	red to white, fine to medium-grained, subangular, 95% qyartz, poorly consolidated, crossbedded (top to east), ledge former, basal contact gradational	27
2	Sandstone	red to white, medium to course-grained, subangular, 90% quartz, regular bedding, conglomerate bed, quartzite pebbles, basal contact covered	76
1	Covered section	covered by valley alluvium, thickness from map	1192
			1400

Unit	Bed	Description	Thickness (feet)
Morrison Formation		$NW\frac{1}{4}$ $NE\frac{1}{4}$ Sec 32 T18S R2E Starting at Gunnison Reservoir Dam	
32	Covered slope		184
31	Conglomerate	like unit #19	32
30	Mudstone	like unit #2	64
29	Sandstone	like unit #27	12
28	Conglomerate	like unit #19	30
27	Sandstone	red, fine-grained, subangular, feldspar 50%, quartz 50%, well cemented, well sorted, basal contact sharp	7
26	Mudstone	like unit #2	12
25	Conglomerate	like unit #19	15
24	Mudstone	like unit #2	23
23	Conglomerate	like unit #19	19
22	Mudstone	like unit #2	5
21	Conglomerate	like unit #19	39
20	Mudstone	like unit #2	19
19	Conglomerate	gray, quartzite pebbles, fine-grained sand matrix, ledge former, basal contact sharp	40
18	Mudstone	like unit #2	21
17	Sandstone	red, medium-grained, subangular, minor amounts pebbles, quartzite, ledge former, basal contact sharp	64
16	Mudstone	like unit #2	26
15	Conglomerate	like unit #3	10
14	Mudstone	like unit #2	33
13	Conglomerate	like unit #3	18
12	Mudstone	like unit #2	17

Unit	Bed	Description	Thickness (feet)
11	Conglomerate	like unit #3	10
10	Mudstone	like unit #2	17
9	Conglomerate	Like unit #3	21
8	Mudstone	like unit #2	51
7	Limestone	like unit #4	7
6	Conglomerate	like unit #3	8
5	Mudstone	like unit #2	35
4	Limestone	red, contains quartz grains,oncolites, massive ledge former, basal contact sharp	7
3	Conglomerate	red; quartzite, limestone, sandstone, conglomerate cobbles; sandy matrix, course-grained quartz, poorly cemented, ledge former, basal contact sharp	40
2	Mudstone	red, contains course subangular quartz grains, no bedding seen, slope former, basal contact gradational	52
1	Sandstone	red, medium to fine-grained, subangular, quartz massive, ledge former, basal contact covered by alluviam	51
			1000

Apapien shale not measured because of poor exposures, no thickness

REFERENCES CITED

Spieker, Edmund M., Late Mesozoic and early Cenozoic History of Central Utah, U. S. Geol. Survey Prof. Paper 205-D, 1946

Students, Ohio State University field camp, especially the Upper Gunnison Group, 1968

Threet, Personal communication, 1968

GEOLOGIC COLUMN

- QAL - ALLUVIUM
- PL - LAKE DEPOSIT
- PG - SORTED GRAVEL
- PDF - DEBRIS FLOW
- QP - PEDIMENT

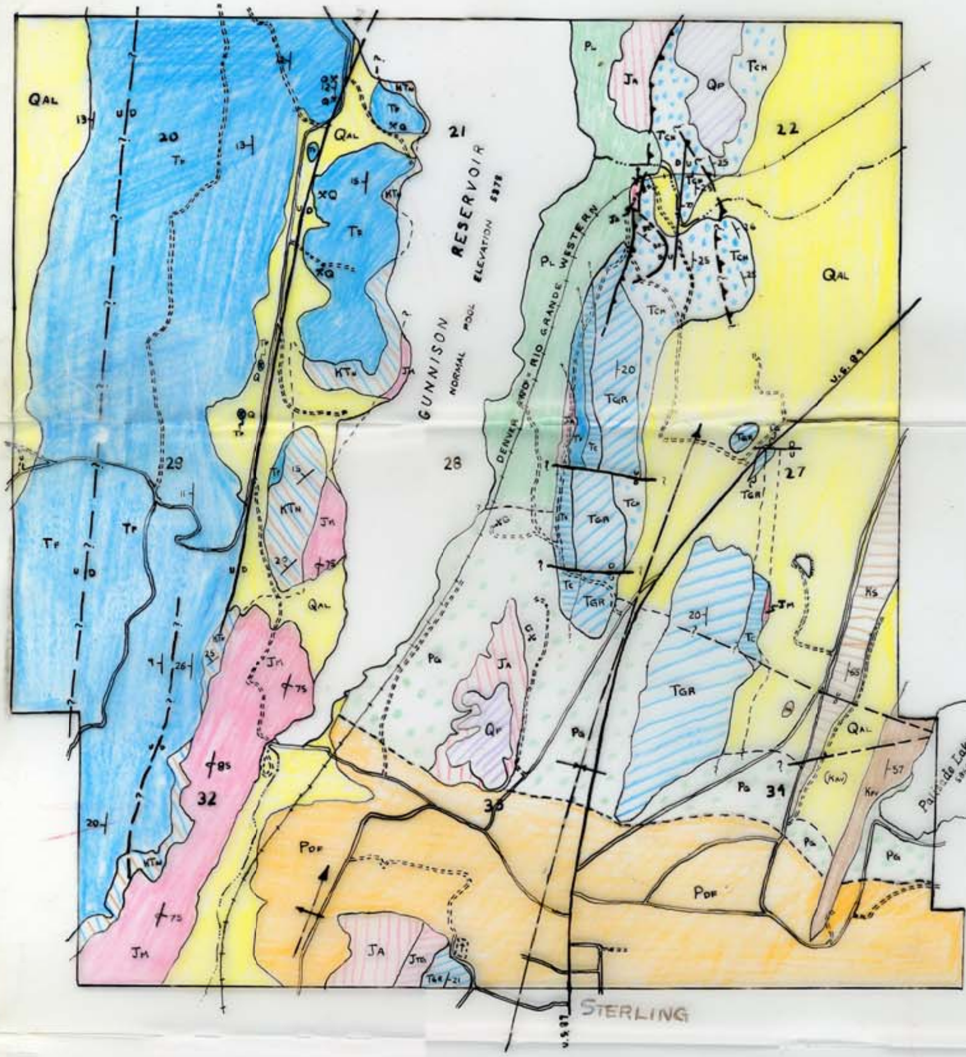
- TCH - CRAZY HOLLOW FM.
- TGR - GREEN RIVER FM.
- TC - COLTON FM.
- TF - FLAGSTAFF FM.

LOCAL UNCONFORMITY

- TKN - NORTH HORN FM.

REGIONAL UNCONFORMITY

- KS - SANPETE SS.
- KAV - ALLEN VALLEY SH.
- KFV - FUNK VALLEY FM.
- JM - MORRISON FM.
- JTG - TWIST GULCH FM.
- JA - ARAPIEN SH.



- GEOLOGICAL CONTACT
- APPROXIMATE CONTACT
- FAULT, SHOWING DIP
- FAULT, EXISTENCE UNCERTAIN
- THRUST FAULT, TEETH ON UPPER PLATE
- THRUST FAULT, EXISTENCE UNCERTAIN
- SYNCLINE, PLUNGING
- ANTICLINE, PLUNGING
- STRIKE + DIP OF BEDDING
- STRIKE + DIP OF OVERTURNED BEDDING
- AXIAL TREND OF SMALL FOLDS
- STREAM
- GRAVEL ROAD
- IMPROVED ROAD
- S.U. 89
- RAILROAD
- XG GRAVEL PIT
- XQ QUARRY

TN

DECLINATION 15°57', 1968

ANNUAL CHANGE 0°03'W

LOWER GUNNISON AREA

SCALE 1:24,000

1 ½ 0 1 MILE

STEVEN KING